Development of Inflation Probe Technologies for the Advanced ACT Experiment

Completed Technology Project (2015 - 2018)

Project Introduction

The Inflationary Model of the universe has provided a theoretical platform for modern observational experiments in the field of cosmology. A well-defined method of probing the properties of inflation, as well as other cosmological science, is through direct measurements of the Cosmic Microwave Background (CMB). In order to achieve future CMB imaging objectives, existing experiments must undergo advanced technological transformations to reach new frontiers in sensitivity, reliability, and performance. The central objective of my project is to develop cutting edge hardware and software technologies for the Atacama Cosmology Telescope (ACT) that will allow the Advanced ACT (AdvACT) experiment to meet the specifications necessary to further our understanding of the properties of the universe. The instrumentation objectives include developing a rotating half-wave plate (HWP) system as well as multi-frequency detector arrays for AdvACT. Once these devices are completed, I will shift my focus to extensive data analysis in order to reap the scientific benefits of the AdvACT instrument. The primary scientific objective of my proposed project will be the measurement of large angular scale B-mode polarization produced by inflationary gravitational waves. To accomplish these objectives, my project is broken into a three phase structure. The first is the completion and deployment of the HWP. I will assemble the mechanical layout of the HWP rotator. I will also build a custom encoder and control/readout box to accompany the HWP. The HWP will finally be deployed and integrated with our data analysis pipeline at the ACT site in Chile. The second phase of my project will be the design and fabrication of new transition edge sensor (TES) bolometer arrays for AdvACT. I will accomplish this by working alongside our collaborators at the National Institute of Standards and Technology (NIST) to design and test detector prototypes. I will also design and build the mechanical structure of detector arrays. Finally, I will deploy the completed detector arrays at the ACT site in Chile. The third phase of my project will focus on the science objectives of the AdvACT experiment. I will accomplish the bulk of my science objectives by learning the current map-making routine from the ACT data analysis team and use this knowledge to lead necessary data analysis routine modifications. The new map-making routine, along with the instrument performance described above, will maintain a platform for achieving our desired science goals. The proposed instrumental and scientific objectives of my project will also directly address a range of NASA interests. Firstly, the HWP will support Instrument Optics objectives from the NASA TABS. The HWP will exhibit features that are unique to the AdvACT instrument, giving future NASA CMB experiments state of the art options for polarization modulation. The HWP will also contribute to NASA's objective of high stability optics development. Secondly, AdvACT detectors will meet almost all of the physical specifications outlined by NASA for an inflationary probe. The detectors will operate at less than 1 Kelvin with an array diameter of approximately 152mm. The total number of pixels across all three arrays will reach ~5800. Once the arrays are completed, I propose to advance the Technology Readiness Level (TRL) of the arrays through direct collaboration

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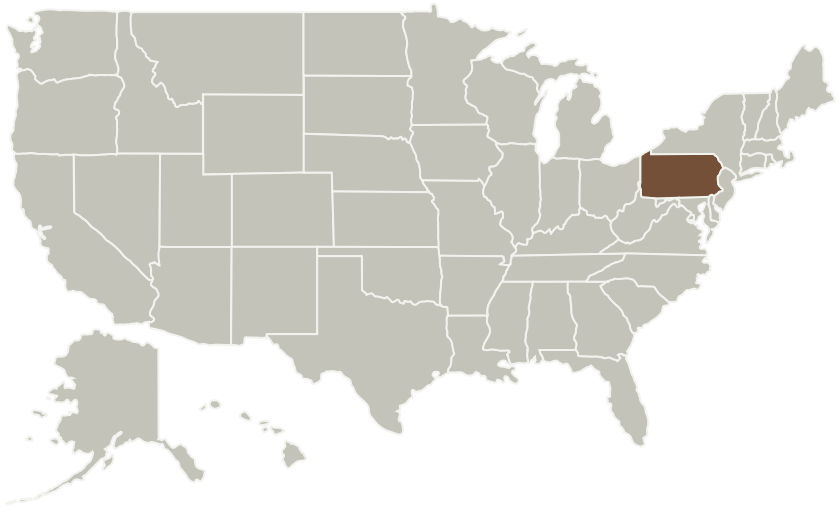
with NASA GSFC. This will allow for substantial interfacing between AdvACT and future NASA orbital experiments through relevant environment testing at Goddard. These tests, along with better understanding of the AdvACT instrument through years of observations and analysis, will provide a clear path to follow for future NASA inflationary probes. More broadly, many aspects of the AdvACT instrument will contribute to NASA's Grand Space Challenges by developing "new tools of discovery".

Anticipated Benefits

Firstly, the HWP will support Instrument Optics objectives from the NASA TABS. The HWP will exhibit features that are unique to the AdvACT instrument, giving future NASA CMB experiments state of the art options for polarization modulation. The HWP will also contribute to NASA's objective of high stability optics development. Secondly, AdvACT detectors will meet almost all of the physical specifications outlined by NASA for an inflationary probe.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Pennsylvania

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Mark J Devlin

Co-Investigator:

Jonathan C Ward

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Organizations Performing Work	Role	Type	Location
University of Pennsylvania	Lead Organization	Academia	Philadelphia, Pennsylvania
National Institute of Standards and Technology(NIST)	Supporting Organization	US Government	Boulder, Colorado

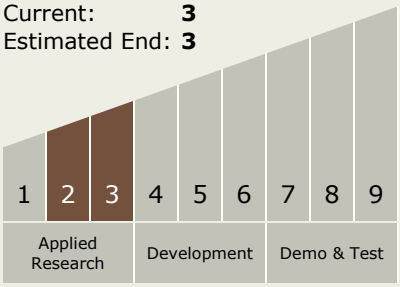
Primary U.S. Work Locations
Pennsylvania

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Others Inside the Solar System